OROVILLE FERC RELICENSING
(PROJECT NO. 2100)

INTERIM REPORT
SP-F21, TASK 4

PREDATION PM&E LITERATURE REVIEW

REVIEW DRAFT

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1.0 SUMMARY

A "reconnaissance level" literature review was conducted to summarize predation management and monitoring studies in order to determine their effectiveness and their potential applicability to the Oroville Facilities. The purpose of the "reconnaissance level" approach for this interim report is to provide an overview and categorization of the variety of types of predation management and monitoring studies, a synopsis of study results and a statement regarding their potential applicability to the Oroville Facilities, in order to allow the Environmental Work Group (EWG) to review the available information and provide guidance on the types of management and monitoring programs that merit further investigation and documentation for the identification and evaluation of potential protection, mitigation or enhancement (PM&E) measures.

A total of 30 different predation management and monitoring studies have been reviewed and summarized in this interim report. The types of predation management studies reviewed thus far fall into the following generalized categories: removal of the predatory species (mainly northern pikeminnow (*Ptychocheilus oregonensis*) using a variety of methods; release of hatchery-reared prey species at varying times and locations; eradication of spawning fish, newly hatched fry, and pikeminnow eggs through a variety of methods; water management regime modifications; predator consumption rate evaluations; model simulations to determine predator and prey interactions; and identification of predatory species characteristics. Of the literature reviewed, it appeared that most of the management plans could conceptually be applied to the conditions at the Oroville Facilities. Most of the predation management literature reviewed did not utilize rigorous scientific methods of sampling or monitoring, nor did they document pre- and post-management implementation conditions. Consequently, most of the reviewed literature provided only qualitative and subjective interpretation of study results. Therefore, the specific potential benefits of implementing any of these plans are not readily quantifiable.

The EWG is requested to identify the specific literature or types of studies that merit a more detailed summary and analysis of applicability to the Feather River and the Oroville Facilities. This guidance will be incorporated into the development of the final report of this task due in December 2003, as well as provide additional focus for the implementation of Tasks 1, 2 and 3 of SP-F21.

2.0 PURPOSE

Artificial structures and project operations associated with the Oroville Facilities may influence predation of juvenile anadromous salmonids by piscivorous fish in the Feather River. Oroville project features and artificial structures may produce turbulence, eddies, and other in-river conditions which are advantageous for predatory species. For example, the Fish Barrier Dam concentrates salmonids by preventing further upstream migration in the main Feather River channel, and this concentration may provide conditions that favor predation. Another project feature that is generally thought to potentially contribute to juvenile salmonid predation is the area of the Feather River affected by turbulence from the Thermalito Afterbay Outlet. Additionally, flow and water temperature regimes associated with project operations may result in habitat alterations that favor predatory species. Therefore, this study was conducted to summarize previously conducted predation management and monitoring plans designed to

decrease predation on juvenile anadromous salmonids and assess their potential applicability to the Feather River and the Oroville Facilities.

The purpose of this study was to compile and summarize PM&E efforts designed to reduce predation or control predatory fish, and to evaluate the success of such measures as well as the potential applicability of such measures to the Feather River and the Oroville Facilities. This task was designed to support the identification of potential PM&Es by summarizing previously implemented PM&Es to reduce predation on juvenile anadromous salmonids from other river systems, and assessing their potential applicability to the Feather River and the Oroville Facilities. Applicability of PM&Es conducted in other river basins to the Feather River was evaluated qualitatively, and the degree of applicability was used to conceptually evaluate the potential value associated with implementing a similar PM&E in the Feather River.

Section 4.51(f)(3) of 18 CFR requires reporting of certain types of information in the FERC Application for License for major hydropower projects, including a discussion of the fish, wildlife and botanical resources in the vicinity of the project. The discussion needs to identify the potential impacts of the project on these resources, including a description of any anticipated continuing impact for on-going and future operation of the project. This interim report also contributes to the fulfillment of this requirement.

3.0 BACKGROUND

The focus of SP-F21 is on artificial structures and habitat alterations associated with the project facilities and operations, which may create in-river conditions favorable to predators. As a result, the geographic extent of the tasks in SP-F21 is defined based on the likely ability of operations to control the factors influencing predation.

This literature review summarizes predation management and monitoring studies conducted in other river basins, and evaluates the applicability of such measures to the Feather River and the Oroville Facilities. The geographic scope of this study is defined by the factors that affect predation, and their relationship to the Oroville Facilities and operations. For those studies that relate to project features and facilities, the geographic scope is defined by the Feather River from the Fish Barrier Dam downstream to the project boundary. For those predation factors that relate to water temperature regimes, the geographic scope is defined by the downstream extent to which water temperatures can be controlled by Oroville Facilities operations. The current downstream extent of this definition is the confluence of the Feather and Yuba rivers. This geographic definition is subject to revision based on the results of SP-E6, which is designed to determine the downstream extent of reasonable control of Feather River water temperatures by the Oroville Facilities. For those predation factors related to flow regimes, the downstream geographic extent is defined by the confluence of the Feather and Sacramento rivers.

The results of this report and the materials collected to support its development also will be utilized as a component of the investigation, analysis and reporting for SP-F5/7 "Evaluation of Fisheries Management on Project Fisheries". The predation information from this report will provide a portion of the basis and documentation for Task 1 – Evaluate the potential effects of fisheries management activities on ESA-listed fish species, and Task 3 – Evaluate the interactions between the Lake Oroville fishery and upstream tributary fisheries.

It should be noted that many of the literature reviews conducted focused on the management of the northern squawfish (*Ptychocheilus oregonensis*) as a predominant predator species. The "squawfish" is now commonly referred to as "pikeminnow". Of the four species of pikeminnow, the northern pikeminnow (*P. oregonensis*) is the most studied. Because the Sacramento pikeminnow (*Ptychocheilus grandis*) appears to be ecologically similar to the northern pikeminnow, observations of northern pikeminnow are expected to be applicable to Sacramento pikeminnow (Brown et al. 1981).

4.0 METHODOLOGY

The purpose of the "reconnaissance level" approach for this interim report is to provide an overview and categorization of the variety of types of predation management and monitoring studies, a synopsis of study results and a statement regarding their potential applicability to the Oroville Facilities, in order to allow the Environmental Work Group (EWG) to review the available information and provide guidance on the types of management and monitoring programs that merit further investigation and documentation for the identification and evaluation of potential protection, mitigation or enhancement (PM&E) measures.

To simplify the recognition of similarities of strategies or approaches utilized in the predation management or monitoring programs, the studies were categorized as: removal of the predatory species; modification of prey species release; eradication of predators at various life stages; water management regime modifications; predator consumption rates; model simulations for predator/prey interactions; and predator species characteristics.

Each study reviewed had varying quantity and quality of information on the types of predatory species targeted, types of prey species, types of predation problems, locus of investigation or management plan, type of mitigation and restoration strategy, as well as the response of the prey to the management plans. Complete citations of the literature reviewed are located in Section 7 of this interim report.

5.0 RESULTS AND DISCUSSION

5.1 REMOVAL OF PREDATORY SPECIES

5.1.1 Fishing Efforts to Remove Predators

PM&Es

Management of Northern Pikeminnow And Implications For Juvenile Salmonid Survival In The Lower Columbia And Snake Rivers

Description

This study evaluated the quantity of northern pikeminnow removed from the lower Columbia and Snake rivers through sport-reward, dam angling, and gill net fishing activities. From 1991 to 1996, the three fisheries harvested approximately 1.1 million northern pikeminnow.

Result

A simple model was developed to estimate predation on juvenile salmonids by northern pikeminnow relative to the predation that would occur without implementation of the pikeminnow control efforts including sport-reward, dam angling, and gill net fishing activities. The model was designed to estimate the effects of these pikeminnow removal efforts if all other factors (e.g., river and ocean conditions, number of migrating juvenile salmonids, turbine mortality, etc.) were held constant. Additionally, this model assumed no compensation (increased growth, fecundity, consumption, etc.) by the remaining northern pikeminnow in response to the sustained removal of pikeminnow. Model inputs included: 1) "average" population structure for northern pikeminnow prior to sustained exploitation; 2) "average" rates of consumption of juvenile salmonids by northern pikeminnow; 3) age distribution adjusted by observed exploitation and natural morality; and 4) an index of age-specific relative predation on juvenile salmonids by northern pikeminnow. Because few juvenile salmonids are consumed by northern pikeminnow less than 250-mm fork length (approximately 5 year of age), this model only evaluated predation by northern pikeminnow greater than 5 years of age. Model output was presented in the form of relative predation for each year, expressed as the percent of predation loss prior to implementation of the northern pikeminnow removal efforts. Modeling results indicated that following the initiation of the northern pikeminnow fishery program, potential predation on juvenile salmonids by northern pikeminnow had decreased 25% (Friesen et al. 1997). Continued monitoring of predation and juvenile salmonid populations was recommended. After examining the preliminary results of the study, the authors also recommended that this management activity not be solely relied on to decrease predation on juvenile salmonids.

Conclusion

Sport-reward angling could be applicable to the Oroville Facilities and the Feather River. However, the results of the activity would not be immediate and continued monitoring would be required to determine the long-term success of the program. Environmental effects of removing pikeminnow from the Feather River and the regulatory, administrative and logistics issues of the implementation of a sport-reward angling program would need to be evaluated. Gill net fishing would most likely not be applicable to the Oroville project, because the removal method is fish species indiscriminant and might adversely affect ESA-listed fish species. Gill net fishing may be adaptable to target larger pikeminnow (greater than 250 mm fork length, as suggested above), but adult steelhead and other adult fish species also may be caught in the gill nets. Thus, an evaluation of the potential effect of gill netting on ESA-listed fish species and other fish species would be required prior to implementation of a pikeminnow removal program.

<u>Evaluation Of The Northern Squawfish Management Program. Final Report Of Research, 1990-1996. Management Of Northern Squawfish And Implications For Juvenile Salmonid Survival In The Lower Columbia And Snake Rivers</u>

Description

This study evaluated the removal of northern pikeminnow along the lower Columbia and Snake rivers through sport-fishery and dam-angling to determine if there was a reduction in predation on juvenile salmonids.

Result

A simple model was developed to estimate predation on juvenile salmonids by northern pikeminnow relative to the predation that would occur without implementation of the pikeminnow control efforts including sport-reward, dam angling, and gill net fishing activities. The model was designed to estimate the effects of these pikeminnow removal efforts if all other factors (e.g., river and ocean conditions, number of migrating juvenile salmonids, turbine mortality, etc.) were held constant. Additionally, this model assumed no compensation (increased growth, fecundity, consumption, etc.) by the remaining northern pikeminnow in response to the sustained removal of pikeminnow. Model inputs included: 1) "average" population structure for northern pikeminnow prior to sustained exploitation; 2) "average" rates of consumption of juvenile salmonids by northern pikeminnow; 3) age distribution adjusted by observed exploitation and natural morality; and 4) an index of age-specific relative predation on juvenile salmonids by northern pikeminnow. Because few juvenile salmonids are consumed by northern pikeminnow less than 250-mm fork length (approximately 5 year of age), this model only evaluated predation by northern pikeminnow greater than 5 years of age. Model output was presented in the form of relative predation for each year, expressed as the percent of predation loss prior to implementation of the northern pikeminnow removal efforts. Modeling results were used to estimate increases in the number of surviving juvenile salmonids that result from sustained exploitation of northern pikeminnow. "Our estimate of percent reduction in potential predation indicates that annual losses may be reduced to 9.4 million, a net gain of 5.8 million juvenile salmonids" (Friesen et al. 1999). The study concluded that managed fisheries are successful at removing large numbers of northern pikeminnow.

Conclusion

Managed fisheries could be applicable to the Oroville Facilities and the Feather River. However, catch rates of the predatory species would need to be determined to evaluate whether or not the program would produce a benefit to salmon. Additional monitoring would be required to determine population response of prey species, and an evaluation would be needed to determine the feasibility of sport-fishing for pikeminnow in the Feather River.

Predator Removal Program

Description

In 1994, DFG and the Department of Water Resources (DWR) proposed to initiate a large-scale striped bass removal project at the Clifton Court Forebay. Tens of thousands of striped bass would be netted from the reservoir and sent in fish transport trucks for release at other locations such as San Pablo Bay.

Result

Striped bass fishing groups opposed the removal project. State agencies could not complete the environmental documentation and the project was not implemented. A more thorough investigation was proposed for 1995. Plans are still on hold for the predatory removal program at the Clifton Court Forebay.

Conclusion

Because the plan has not been implemented, it is unknown at this time if any of the removal methods could be applicable to the Oroville Facilities and the Feather River. The Oroville project may benefit from this information in the evaluation of predation PM&E's developed to anticipate potential conflicts with the environmental documentation, fisheries management stakeholders and implementation challenges.

Evaluation Of Harvest Technology For Squawfish Control In The Columbia River Reservoirs

Description

This study evaluated the removal of northern pikeminnow from various Columbia River reservoirs with floating trap nets and electrofishing to determine the effectiveness of each method.

Results

Floating trap nets were found to be an effective method of removal on a large scale (removed over 5,500 pikeminnow during the 1992 season of April to August) in areas of relatively moderate current at a depth of approximately 30 feet. Electrofishing was most successful in midreservoir locations (over 29,000 fish affected in the 1992 season); however, there is a large amount of incidental catch through this method, as well as some injuries to the fish (Iversen et al. 1994). The authors concluded that both methods were effective at removing large numbers of pikeminnow. They also concluded that there is room for improvement in the electrofishing technique.

Conclusion

These methods may be applicable to the Oroville Facilities and the Feather River if the methods could be adapted and managed to reduce or eliminate potentially adverse effects on ESA-listed fish species in the Feather River.

Feeding Activity, Rate Of Consumption, Daily Ration And Prey Selection Of Major Predators In John Day Reservoir

Discussion

This study evaluated a variety of predator control and prey protection measures that have been used in previous studies in order to determine the effectiveness of each measure. Use of seines was one management practice evaluated. The trap-based predation study is profiled below.

Result

Seines used in Cultus Lake resulted in a 10% decrease in the northern pikeminnow population and a 2.5% increased survival rate in young salmon (Gray et al. 1984). It is suggested, however, that seines be used with caution, as they scour the bottom fauna and could adversely affect fish habitat.

Conclusion

Seining for predator removal might be applicable to the Oroville Facilities and the Feather River. However, potential impacts to ESA-listed fish species, habitat impacts, and the amount of seining required to accomplish a specific predator reduction and prey survival improvement goal would need to be evaluated.

Feeding Activity, Rate Of Consumption, Daily Ration And Prey Selection Of Major Predators In John Day Reservoir

Discussion

This study evaluated a variety of predator control and prey protection measures that have been used in previous studies in order to determine the effectiveness of each measure. Devices evaluated included trapnets, hoopnets, trawls, fyke nets, and gillnets. The studies evaluated took place over periods ranging from 1 year to 15 years, and were conducted in ponds and lakes at various locations ranging in size from 1 ha to 55,730 ha.

Result

In different studies completed, trapping was effective at reducing the number of the target species as well as the average age of the target species (freshwater drum, bigmouth buffalo, carp, northern pike, black crappie, black bullhead, yellow perch, white perch). However, in some of the studies, there was an increase in growth rate of the target species as well as an increase in the gamefish population. Trapping is considered advantageous over other methods due to its affordability, allowing for control of size and species being removed, and little or no impact on the abiotic environment. Trapping limitations include its potential inability for use in highly turbulent tailwaters (where predators are often found) and seasonal movements of predators out of areas accessible to traps.

Conclusion

This type of predator removal may be applicable to the Oroville Facilities and the Feather River. The site requirements, success at species and size selection, typical catch rates under application conditions, and estimates of the number of predators that would need to be removed from the Feather River in order to achieve a defined goal for increased juvenile salmonid survival would need to be developed.

Research Supporting Implementation/Evaluation Of Fishing PM&Es

Predation By Resident Fish On Juvenile Salmonids In A Mainstem Columbia Reservoir: Part IV. Estimated Total Loss And Mortality Of Juvenile Salmonids To Northern Squawfish, Walleye, And Smallmouth Bass

Description

This study estimated the loss of juvenile salmonids and steelhead to northern pikeminnow, walleye, and smallmouth bass using daily prey consumption and predator abundance from 1983 to 1986. Mortality was estimated by dividing the loss estimate numbers (resulting from

multiplying estimates of daily prey consumption by predator number) by the estimated numbers of salmon and steelhead passing the dam plus those released from the hatchery during the period of migration (April–August).

Result

Based on the prey consumption estimates generated from previously completed studies, mean annual loss of juvenile salmonids from predation by northern pikeminnow, walleye, and smallmouth bass was 2.7 million fish (Reiman et al. 1988). Predation by resident fish predators can easily account for previously unexplained mortality of juvenile salmonids.

Conclusion

Elements of this study may be applicable to the Oroville Facilities and the Feather River if estimates of prey consumption were needed. Evaluation of the suitability and quality of prey consumption estimate results would need to be conducted prior to further consideration of this method.

Development Of A System Wide Predator Control Program: Indexing And Fisheries Evaluation

Description

This study collected northern pikeminnow with gillnets and electrofishing to develop an index of northern pikeminnow abundance downstream of the Bonneville Dam tailrace on the Columbia River. The index of northern pikeminnow abundance was calculated as the product of density and surface area.

Result

Based on the sampling, the predation index was higher downstream from the Bonneville Dam tailrace than upstream at John Day Reservoir (Parker et al. 1993). Sampling will continue after the removal of northern pikeminnow to determine if there are any changes in the northern pikeminnow population (e.g., size, spawning activity, year class strength, etc.)

Conclusion

Predator "indexing" could be applied to the Oroville Facilities and the Feather River. However, the abundance of the predation population must be determined prior to any predator management program implementation, and continued monitoring would be required after removal of predatory species to provide an "index" of effectiveness.

Response Of Smallmouth Bass To Sustained Removals Of Northern Pikeminnow In The Lower Columbia And Snake Rivers

Description

This study described the response of smallmouth bass density, year-class strength, consumption of juvenile salmonids, mortality, relative weight, and growth to sustained removals of northern pikeminnow during the *Evaluation of the Northern Squawfish Management Program, Final Report of Research, 1990-96* (Ward et al. 1997).

Result

Over 1.1 million northern pikeminnow were removed from the Columbia River basin from 1991-1996. Subsequent to pikeminnow removal, consumption of juvenile salmonids remained low. Additionally, based on the data collected before and after the northern pikeminnow removal, there was no change in the smallmouth bass population (Ward et al. 1999). "Smallmouth bass are the most abundant and widespread predator other than northern pikeminnow in the lower Columbia and Snake rivers, and therefore have high potential for reducing benefits of the (pikeminnow) management program" (Ward, et al. 1997). Lack of response of smallmouth bass provides support for the hypothesis that sustained removal of northern pikeminnow increases survival of juvenile salmonids.

Conclusion

Removal of the northern pikeminnow could be applicable to the Oroville Facilities and the Feather River. However a long-term study would need to be conducted to determine the response to the removal by other fish, including smallmouth bass. The overall ecosystem effect of removing pikeminnow from the Feather River also would need to be evaluated prior to implementation of any predator removal program.

Simulation Of Predation By A Resident Fish On Juvenile Salmonids In A Columbia River Reservoir

Description

This study developed and tested a model of predation by northern pikeminnow on juvenile salmonids migrating through the John Day Reservoir. The model predicted mortality as a function of the number and distribution of predators, number of prey entering the reservoir, the residence time of the prey, water temperature and flow.

Result

The model predicted that mortality estimated by previous studies from 1983-1986 was similar to that expected over a longer term, based on the normal annual variation in the number of northern pikeminnow present, water temperature, and flow. Based on modeling results, it appeared the best ways to reduce predation is to reduce the number of predators, pass salmonids earlier in the year, and maintain runs equal to or greater than present levels.

Conclusion

Elements of this study's conclusions regarding manipulation of variables that effect predation could potentially be applicable to the development strategy for a predation management PM&E measure for the Feather River.

Management Implications Of A Model Of Predation By A Resident Fish On Juvenile Salmonids Migrating Through A Columbia River Reservoir

Discussion

This study constructed a model of predation of migrating juvenile salmonids by northern pikeminnow. The model predicted salmonid survival as a function of the number and

distribution of northern pikeminnow, number and timing of juvenile salmonids entering the reservoir, salmonid residence time, water temperature, and flow.

Result

Based on the modeling, the survival of juvenile salmonids was near the average predicted from 30 years of historic environmental data (Beamesderfer et al. 1990). Sensitivity analyses preformed implied that the best methods for reduction of predation can include measures such as: (1) reduce the number of northern pikeminnow; (2) pass salmonids earlier in the year; and (3) maintain sizes of runs of juvenile salmonids at or above present levels. The model simulations also showed that survival of the salmonids is weakly affected by changes in predator distribution, changes in predator consumption rate near the upstream dam, residence time, or flow.

Conclusion

Elements of this study's conclusions regarding manipulation of variables that effect predation could potentially be applicable to the development strategy for a predation management PM&E measure for the Feather River.

Population Dynamics Of Northern Squawfish And Potential Predation On Juvenile Salmonids In A Columbia River Reservoir

Description

This study described growth, mortality, and variation in year-class strength of northern pikeminnow to better understand predation. The model used simulations to describe expected changes in predation caused by variation in recruitment or by exploitation (removal of the predator).

Result

Modeling simulations showed growth of the northern pikeminnow was high relative to other populations, mortality uncertain, and year-class strength varied, but was negatively associated with the concurrent year-class strength of walleye. Simulated predation declined with the exploitation of the northern pikeminnow. Sustained exploitation of 10%-20% annually reduced predation by 50% or more (Reiman et al. 1988). The study was uncertain about the resilience of northern pikeminnow populations and some risks exist that any exploitation could aggravate predation if the exploitation is not sustained. Any control program should evaluate changes in the predator's population, and long-term studies will be required to distinguish changes in predation caused by predator removal.

Conclusion

Elements of this study's conclusions on how to manipulate variables that effect predation could potentially be applicable to the development strategy for a predation management PM&E measure for the Feather River.

Dynamics Of A Northern Squawfish Population And The Potential To Reduce Predation On Juvenile Salmonids In A Columbia River Reservoir

Description

This study used simulation models to determine the potential influence of the removal of northern pikeminnow on the predation of salmonid smolts, and if there would be a reduction in predation.

Result

The study found through model simulations that potential predation declined with sustained exploitation in all simulations. Simulated predation declined with exploitation of fish larger than 275 mm FL, which is equivalent to a reduction in predation of 50% or more with exploitation of 10-20% of the predator population annually (Reiman et al. 1990). However the analysis was found to have important uncertainties. It assumed no compensation in growth or mortality of exploited northern pikeminnow. Predation by northern pikeminnow may be reduced through exploitation, but the potential for rapid recovery of the predator population may present a problem in short-term control programs implemented. Further research is needed. Control programs implemented should include research to document compensation in predator populations and the fish community.

Conclusion

Elements of this study's conclusions regarding manipulation of variables that effect predation could potentially be applicable to the development strategy for a predation management PM&E measure for the Feather River.

<u>Evaluating Enhancement Of Striped Bass In The Context Of Potential Predation On Anadromous Salmonids In Coos Bay, Oregon</u>

Description

This study evaluated the predation on salmonids that could result from the enhancement of striped bass using the estimated losses of salmonids documented in 1950 and 1960-1964 in Coos Bay and information about striped bass in other waters.

Result

Based on the predation estimates from previous consumption (stomach content) studies, large striped bass populations may limit enhancement options for anadromous salmonids. "Estimated numbers of juvenile salmonids consumed by striped bass in Coos Bay ranged from 41,000 in 1950 to about 383,000 in 1963" (Johnson et al. 1992). The effort to estimate salmonid losses from striped bass predation is useful in addressing the fisheries management issue, as this analysis allowed the managers to reach their decision on the striped bass enhancement program with the knowledge of its potential consequence to the salmonid population.

Conclusion

Some elements of the methods for estimating salmonid consumption by striped bass could be applicable to the Feather River if a specific effort to quantify their predation was deemed warranted.

5.1.2 Non-Fishing Predator Removal

PM&Es

The Control Of Squawfish By Use Of Dynamite, Spot Treatment, And Reduction Of Lake Levels

Description

Dynamite was used in northern Idaho waters to eradicate spawning pikeminnow. Newly hatched fry were eradicated by partial treatment with Fish Tox and rotenone. Reduction of water surface elevation at Hayden Lake, Idaho, took place to eradicate pikeminnow eggs.

Result

Lowering the water surface elevation at Hayden Lake 2 inches per day after surface temperatures reach 60°F destroyed virtually all pikeminnow eggs (Jeppson 1957). Dynamite and Fish Tox eradicated virtually all spawning pikeminnow and newly hatched fry.

Conclusion

Methods evaluated in this study are not likely to be very applicable to the Oroville Facilities because the majority of predation occurs in the Feather River from resident pikeminnow, so lowering the flow levels to disrupt spawning is probably not viable. Additionally, applications of Fish Tox or use of dynamite in the Feather River, where ESA-listed fish species are present, would most likely not be deemed acceptable.

Feeding Activity, Rate Of Consumption, Daily Ration And Prey Selection Of Major Predators In John Day Reservoir

Description

This study evaluated a variety of predator control and prey protection measures that have been used in previous studies in order to determine the effectiveness of each measure. Use of chemical control measures to reduce the predator population was one such management practice evaluated.

Result

Fish toxicants (piscicides) have been used in the United States since the 1930s to manipulate fish communities, but tend to have extensive side effects to the surrounding biological community. In the 1950's, squoxin was developed for use on squawfish and sea lamprey. "Squoxin was found to be a selectively lethal toxicant to northern and Umpqua pikeminnow through a large scale screening program" (Gray et al. 1984). Laboratory tests of selectivity indices of squoxin (LC_0/LC_{100}) found that the higher concentration of squoxin, the less likely the non-targeted (prey) species will be affected. However, timing of the application of squoxin is critical due to water temperature being positively correlated with the toxicants effectiveness and selectivity. In the Columbia River system, the best time for application of squoxin appears to be when water temperatures reach 20°C or higher. Squoxin is relatively non-toxic to other organisms, is easy and relatively safe to apply, and degrades over 90% within 7 hours of application. A squoxin

application of 50µg/L in 56 km of the North Fork of the John Day River resulted in a complete eradication of the northern pikeminnow population (Gray et al. 1984). Squoxin is currently not registered.

Conclusion

Lack of registration or common usage of this material indicates that it is not likely to represent a successful solution to species-specific fish predator management. Further investigation would be required to determine if squoxin is indeed pikeminnow-specific and to determine the actual mode of action. Consideration of the use of a piscicide would likely require significant efforts and costs for an EIR as well as public relations communications and education.

5.1.3 Prey Species Release Measures

PM&Es

Effectiveness Of Predator Removal For Protecting Juvenile Fall Chinook Salmon Released From Bonneville Hatchery

Description

This study evaluated the release of subyearling Chinook salmon from Bonneville Hatchery, which is located 1 km downstream from Bonneville Dam. The subyearling Chinook salmon were released four days apart at Tanner Creek (400 m downstream from hatchery) and in the midstream Columbia River to determine individual survival rates.

Result

Through stomach content examination of predator species caught within the vicinity of the salmonid release locations, a predator consumption rate for each location was calculated. Based on the comparison of the predator consumption rate at the two release locations, it was determined that salmonids released midstream had higher survival rates than those released at the hatchery (Ledgerwood et al. 1994).

Conclusion

Because hatchery-reared juvenile Chinook salmon are not currently planted in the Feather River directly, the results of this study are not likely applicable to juvenile Chinook salmon releases. However, elements of this study, such as an alteration of the instream release location of juvenile salmonids, may be applicable to release of hatchery-reared juvenile steelhead in the Feather River, as these salmonids are directly planted in the Feather River. Caution should be used in applying results of a study focused on juvenile Chinook salmon to an operation focused on juvenile steelhead.

Feeding Activity, Rate Of Consumption, Daily Ration And Prey Selection Of Major Predators In John Day Reservoir

Discussion

This study evaluated a variety of predator control and prey protection measures that have been used in previous studies in order to determine the effectiveness of each measure. Altering the release conditions for the juveniles was another management procedure evaluated in this study.

Result

Previous studies have evaluated whether or not light has an effect on predator feeding activity. A study completed at the Red Bluff Diversion Dam found that predation on juvenile salmonids by pikeminnow was greater during day-time release of juveniles than during night-time release, when the dam lights were turned off (Gray et al. 1984). However, additional studies are needed to determine the rate of survival by releasing the juveniles at night with the dam lights on versus with the dam lights off.

Conclusion

Because hatchery-reared juvenile Chinook salmon are not currently planted in the Feather River directly, the results of this study are not likely applicable to juvenile Chinook salmon releases. However, elements of this study, such as time of day of release, may be applicable to release of hatchery-reared juvenile steelhead in the Feather River, as these salmonids are directly planted in the Feather River.

Research Supporting Implementation/Evaluation Of Prey Species Release PM&Es

Changes In Catch Rate And Diet Of Northern Squawfish Associated With The Release Of Hatchery Reared Juvenile Salmonids In A Columbia River Reservoir

Discussion

This study investigated the distribution and predation activities of northern pikeminnow at three locations where hatchery-reared juvenile salmonids were released. The sites were located along the Columbia River at river km 269, river km 261, and river km 248. All locations were within Bonneville Pool.

Result

A significant increase in northern pikeminnow catch rate occurred at all three locations after release of hatchery-reared juvenile salmonids. Timing and duration of elevated catch rates appeared to be closely related to the release and residence time of the hatchery-released fish in the sampling area. Northern pikeminnow aggregate to feed on hatchery-released juvenile salmonids in the spring. Management activities recommended from this study to reduce predation include: (1) remove predators from concentrated areas, specifically near hatchery release points; (2) release hatchery fish that are larger; and (3) change hatchery release plans to reduce the residence time of hatchery fish at release location. However, further investigations will be required once any of these management plans is implemented.

Conclusion

Because hatchery-reared juvenile Chinook salmon are not currently planted in the Feather River directly, the results of this study are not likely applicable to juvenile Chinook salmon releases.

However, elements of this study, such as variation in release location, may be applicable to release of hatchery-reared juvenile steelhead in the Feather River, because these salmonids are directly planted in the Feather River.

Predation By Resident Fish On Juvenile Salmonids In John Day Reservoir, Part II, Consumption Rates Of Northern Squawfish, Walleye, Smallmouth Bass, And Channel Catfish

Description

This study evaluated the consumption rates of northern pikeminnow, walleye, smallmouth bass, and channel catfish on juvenile Pacific salmon and steelhead to determine when high consumption rates occur.

Result

Based on consumption rate evaluations, it was found that high consumption of juvenile salmon occurred during July, and during night and early morning hours. Based on stomach contents and digestive rate relationships, the predator with the highest consumption rate was the northern pikeminnow. Various management activities, such as: (1) removal of the predatory species; (2) altering timing of flows; and (3) optimizing the seasonal timing of the juvenile salmonid out-migration, have been used successfully in previous studies to reduce the consumption rate of the predators. Based on the study's consumption rate conclusions and the results from previous studies, it was recommended that juvenile salmonids be released during peak consumption rate periods in order to overwhelm predator consumption rate capacity, and thereby reduce overall mortality to the juvenile outmigrant salmonid population. The study also recommended increasing flows during peak migration of the subyearlings, and earlier release of hatchery-reared subyearlings.

Conclusion

Because hatchery-reared juvenile Chinook salmon are not currently released in the Feather River directly, the results of this study are not likely applicable to juvenile Chinook salmon releases. However, elements of this study, such as variation in release timing based on predator consumption rate, may be applicable to release of hatchery-reared juvenile steelhead in the Feather River, as these salmonids are directly planted in the Feather River.

Functional Response Of Northern Squawfish Predation To Salmonid Prey Density In McNary Tailrace, Columbia River

Description

This study evaluated the functional response of northern pikeminnow consumption rate to smolt density during migrations (April-August) in the tailrace of McNary Dam, through stomach content examination of the northern pikeminnow.

Result

Based on the consumption rates, determined through stomach content examinations, it appeared that pikeminnow rapidly changed from a non-salmonid diet to an almost exclusively salmonid smolt diet, at relatively low smolt densities. Also, salmonids were always preferred as a food

item, regardless of their density. Further research on pikeminnow consumption rates at high prey densities and better estimates of the number of smolts passing through McNary Dam are needed to refine the functional response relationship.

Conclusion

Because hatchery-reared juvenile Chinook salmon are not currently released into the Feather River directly, the results of this study are not likely applicable to juvenile Chinook salmon releases. However, elements of this study, such as variation in the density of salmonids released, may be applicable to release of hatchery-reared juvenile steelhead in the Feather River, because these salmonids are planted directly into the Feather River. The results of this study would not likely be applicable to the in-channel population of juvenile Chinook salmon and steelhead, because no control mechanisms exists to manipulate their densities in the mainstem of the Feather River.

5.2 HABITAT ALTERATIONS

5.2.1 PM&Es

Water Velocity Manipulations

Significance Of Selective Predation And Development Of Prey Protection Measures For Juvenile Salmonids In The Columbia And Snake River Reservoirs; Report 5, Prolonged Swimming Performance Of Northern Squawfish, Can Water Velocity Be Used To Reduce Predation On Juvenile Salmonids At Columbia River Dams?

Description

This study used varying high water velocities in a stamina tunnel to determine the prolonged swimming performance of the northern pikeminnow, in order to determine how to exclude or limit predation by northern pikeminnow in the area of fish bypass outlets.

Result

This method appeared promising during the spring and early summer outmigrations. Based on the varying water velocities the northern pikeminnow were subjected to in the stamina tunnel, swimming performance time estimates suggest that northern pikeminnow were not able to maintain position at water velocities above 150 cm/s (4.90 ft/s) (Mesa et al. 1993). This study recommended construction or modification of existing bypass facilities to include an area of high water velocity.

Conclusion

Although the Oroville Facilities have no bypass facilities, the results of this study may be applicable to other project structures at which flow, and thereby velocity, can be manipulated, such as the Thermalito Afterbay Outlet. Additionally, it may be possible to modify the flow regime in certain locations or at certain times of the year in order to prevent pikeminnow from maintaining position, but the effects of water velocity manipulations on fish populations other than pikeminnow would need to be evaluated.

Water Temperature Manipulations

Feeding Activity, Rate Of Consumption, Daily Ration And Prey Selection Of Major Predators In John Day Reservoir

Discussion

This study evaluated a variety of predator control and prey protection measures that have been used in previous studies in order to determine the effectiveness of each measure. Water temperature variations within the species habitat to reduce the species population is one predator management measure evaluated in this study.

Result

Water temperature variations, usually brought on by fluctuating water surface levels, can reduce the reproductive success of predator species by inundating spawning and/or nursery areas with cool water. Water temperature reduction can prevent or delay spawning activity, and reduce the survival of the fry and eggs. In the Hanford Reach area of the Columbia River, water surface level fluctuations resulted in cold water entering the smallmouth bass spawning areas. The effects were that sexual maturation of the adults was altered, an increase in nest abandonment occurred, spawning was delayed, and egg development was halted. In addition, smallmouth bass fry became vulnerable to thermal stress (Gray et al. 1984).

Conclusion

Elements of this study, such as alteration of water temperature to disrupt predator spawning or incubation of predator eggs, may be applicable to the Feather River. Using water temperature manipulations to make habitat conditions less favorable to predator species may be applicable to the Feather River, provided that the effects of water temperature manipulations on existing fish populations, including ESA-listed fish species, were evaluated. Additionally, the above study does not suggest the potential benefit that may be achieved by using this type of approach for predators other than smallmouth bass. Caution should be used in applying results of a study focused on smallmouth bass to an operation focused on other fish species such as pikeminnow or striped bass.

Introduced Fisheries Management Strategies

Discussion

This study evaluated proposed measures to be potentially implemented to reduce the population of introduced fish species within the waterways of Oregon. One such proposal was the use of water temperature alterations to reduce the feeding activity of predators.

Result

The Oregon Department of Fish and Wildlife in cooperation with the U.S. Army Corps of Engineers is proposing a strategy to reduce pikeminnow predation of salmonids on the Rogue River through the release of cool water from upstream reservoirs. It is thought that the cool water will decrease the metabolic rate of the pikeminnow, and thus reduce predation. It was noted that use of this strategy must take into consideration the potential water temperature effects

that could occur to native species within the waterways. Presently, this measure is a proposal and no studies have been completed to determine the success rate of this management strategy.

Conclusion

Elements of this study, such as alteration of water temperature to reduce predator feeding, may be applicable to the Feather River, provided that the effects of water temperature manipulations on existing fish populations, including ESA-listed fish species, were evaluated. Additionally, the above study does not suggest the potential benefit that may be achieved by using this type of approach for reduction of predation because it is only in the proposal stage, and therefore provides no monitoring results with which to evaluate the potential benefit that would result from water temperature manipulations.

Chemical or Electrical Predator Avoidance Barriers

Feeding Activity, Rate Of Consumption, Daily Ration And Prey Selection Of Major Predators In John Day Reservoir

Discussion

This study evaluated a variety of predator control and prey protection measures that have been used in previous studies in order to determine the effectiveness of each measure. Use of electrical barriers or chemicals to establish zones where fewer predators reside to protect the prey is one management strategy evaluated in this study.

Result

Repelling predators from certain areas can be achieved through a variety of methods including using electrical barriers and chemicals (such as pheromones). Laboratory test have shown success for blocking the passage of adult northern pikeminnow through the use of electrical barriers. Pheromones can be used to lure predators away from an area or for repelling them as well. One study showed success in repelling northern pikeminnow through use of fright or alarm type pheromones released, but the success was short term. Additional studies evaluated have shown that the use of turbulence and acoustics resulted in a low rate of success for creating a predator-restricted zone (Gray et al. 1984).

Conclusion

Installation of electric barriers to predators is likely not feasible in the Feather River, as the electric barrier has the potential to affect all fish species and is therefore not selective. The use of chemical attractants or repellents may be applicable to the Feather River, provided an evaluation of the effects of using such chemicals on existing fish populations is conducted.

5.2.2 Research Supporting Implementation/Evaluation of Habitat Alteration PM&Es

Water Temperature Manipulations

Temperature Dependent Maximum Daily Consumption Of Juvenile Salmonids By Northern Squawfish (*Ptychocheilus oregonensis*) From The Columbia River

Description

Northern pikeminnow were collected by electroshocking in the Columbia River, and subsequently were tested for their rate of consumption of juvenile Pacific salmon under varying water temperatures in the laboratory.

Result

Based on the consumption of prey species under varying water temperatures, it appeared that maximum daily ration for the northern pikeminnow increased with increases in water temperature near the preferred temperature (20-24°C) of the species, and declined to near zero just below the maximum lethal temperature (27-29°C) of the species (Viggs et al. 1991).

Conclusion

The relationship of consumption rate of northern pikeminnow to water temperature suggested in this study may provide a foundation for evaluating the potential benefits of PM&Es designed to alter water temperature to reduce predator feeding. The results of this study may be applicable to the Feather River, as an evaluation tool. However, it is not likely that water temperature increases in the Feather River is feasible in consideration of existing fish populations

5.3 BEHAVIORAL DISRUPTION

5.3.1 Spawning Disruption

Feeding Activity, Rate Of Consumption, Daily Ration And Prey Selection Of Major Predators In John Day Reservoir

Discussion

This study evaluated a variety of predator control and prey protection measures that have been used in previous studies in order to determine the effectiveness of each measure. One such predator control measure was the use of sterilization of a portion of one sex of the species in order to reduce the population of the predators.

Result

Sterilization of a portion of one sex of a species, usually the males, has shown success in reducing the population of that species. Successful studies have been completed in the past for insects and parasitic sea lampreys (Gray et al. 1984). If the methods for sterilization are carried out carefully, there should be no threat posed to the surrounding environment. Sterilization in large numbers can be achieved through feeding, injection of chemicals, or artificial propagation of genetically sterile individuals. These studies found, however, that sterilization appears to work best on populations where mating is monogamous and there is a large parental investment in finding a mate, courting, nest building, and other energetic behaviors. Additionally, the presence of only a small proportion of sterile males will have little effect on a population of polygamous breeders in which several males mate with one female.

Conclusion

Although sterilization should pose no threats to the environment, control of pikeminnow is relatively difficult because several males usually spawn with a single female. Additionally, in the Feather River, pikeminnow is one of the most numerous species, meaning that large numbers would have to be sterilized in order to precipitate an effect. Although the potential benefit of sterilization would be difficult to quantify, elements of this study may be applicable to predatory species in the Feather River.

5.3.2 Incubation Disruption

Feeding Activity, Rate Of Consumption, Daily Ration And Prey Selection Of Major Predators In John Day Reservoir

Discussion

This study evaluated a variety of predator control and prey protection measures that have been used in previous studies in order to determine the effectiveness of each measure. One such predator control measure was the use of water surface level fluctuations to destroy the spawning grounds, the eggs, and the nest of the predatory species.

Result

Studies that took place at a variety of lakes noted that the lowering of water surface elevations resulted in deterioration of ova with subsequent low year-class strength, reduction in reproductive success (for carp with draw downs of 0.5-0.6 meters lasting 5-9 days), dewatering of spawning areas, reduction in hatching success, preventing of the species reaching the preferred spawning area, and high mortality in early embryonic development (Gray et al. 1984). However, the studies noted that manipulation of water levels is most effective with those species that spawn in shallow water, are reproductively stenothermal, and/or have fry stages that require shallow water during development.

Conclusion

The results of this study are not likely applicable to the Feather River, because altering the flow regime in the river by decreasing flows would affect many fish species in the Feather River. Depending upon the time of year, decreased flow could result in the dewatering of redds of ESA-listed salmonid species, or could result in juvenile or fry stranding. Reducing flow also has the potential to reduce the quantity of available inundated littoral habitat used by splittail and other species as nursery. As a result, decreasing flows in order to disrupt egg incubation is probably not a viable alternative in the Feather River.

5.3.3 Predator Avoidance Training

Training Of Juvenile Salmonids To Avoid Predators

Feeding Activity, Rate Of Consumption, Daily Ration And Prey Selection Of Major Predators In John Day Reservoir

Discussion

This study evaluated a variety of predator control and prey protection measures that have been used in previous studies in order to determine the effectiveness of each measure. One such predator control measure was the conditioning of juvenile salmonids to avoid predators.

Result

Hatchery fish are not exposed to predators, so they become more susceptible to predation once released from the hatchery. One way to help increase their survival is to condition the juveniles to avoid predators. Studies have shown that sight plays an important role in conditioning the juvenile salmonids to avoid predators, and a defense response is usually stronger in a fish that sees its attacker. Models run on defense responses of conditioned and unconditioned fish have shown that death of those fish conditioned to avoid predators was one-third that of the unconditioned fish over the same time period (Gray et al. 1984). Studies also have shown that juveniles conditioned over a 16-day time period retained their conditional response to predators for months without additional stimuli.

Conclusion

Training of hatchery-reared juvenile salmonids may be applicable to juvenile steelhead released from the Feather River Hatchery. Additional review would be required to evaluate the potential benefit of such training.

Overall Predation PM&E

Managing Fish Predators And Competitors: Deciding When Intervention Is Effective And Appropriate

Description

This study highlights a description of the decision-making process recommended to evaluate the applicability of PM&E measures designed to reduce predation. The decision-making process recommends consideration of: 1) the likely importance of predation or competition; 2) the ability of changes in harvest or other management actions to affect potential predators or competitors; and 3) whether or not biological benefits outweigh costs and social/political considerations.

Result

It is difficult to implement an effective intervention program. Intervention benefits are small unless most of the target species can be affected and the effect can be sustained. Economic, political, and social issues compound consideration of any intervention effort.

Conclusion

If a management/intervention program is implemented for predation in the Feather River, all aspects of the program including political, social, biological, benefits, and potential adverse effects must be considered before implementation.

6.0 CONCLUSIONS

Of the literature reviewed, it appeared that most of the management plans could conceptually be applied to the conditions at the Oroville Facilities and the Feather River. Most of the predation management literature reviewed did not utilize rigorous scientific methods of sampling or monitoring, nor did they document pre- and post-management implementation conditions. Most of these studies provided only qualitative and subjective interpretation of their results. As a result, the specific potential benefits of implementing any of these plans is not readily quantifiable.

The EWG is requested to identify the specific literature or types of studies that merit a more detailed summary and analysis of applicability to the Feather River. This guidance will be incorporated into the development of the final report of this task due in December, 2003 as well as provide additional focus for the development of Tasks 1, 2 and 3 of SP-F21.

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